Hospitalaria

Original / *Valoración nutricional*

Subscapular and triceps skinfolds reference values of Hispanic American children and adolescents and their comparison with the reference of Centers for Disease Control and Prevention (CDC)

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Abstract

Introduction: **the assessment of the skinfold thickness is an objective measure of adiposity. Therefore, it is a useful tool for nutritional diagnosis and prevention of metabolic risk associated with excess fat in chilhood and adolescence.**

Objective: **to provide percentiles of subscapular and triceps skinfolds for Hispanic American schoolchildren and compare them with those published by the Centers for Disease Control and Prevention (CDC) from United States, that it have been commonly used as a reference in most of these countries.**

Methods: **subscapular and triceps skinfolds were measured in 9.973 schoolchildren 4-19 aged from Spain, Argentina, Cuba, Venezuela and Mexico with Holtain caliper with 0.2 mm accuracy. Percentiles were obtained with the LMS statistical method and were presented in tables divided in stages of 6 months and in curves graphics. The difference between Hispanic American and CDC mean values were provided for P3, P50 and P97 in mm and also were graphically represented.**

Results: **skinfolds measurements obviously increased with age in both sexes but, in boys, this increase is much more marked in highest percentiles between 8 and 13 years; this maximum is reached earlier than what occurs in CDC reference. In both sexes, all percentiles**

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VALORES DE REFERENCIA PARA LOS PLIEGUES ADIPOSOS SUBESCAPULAR Y TRICIPITAL DE NIÑOS Y ADOLESCENTES HISPANOAMERICANOS Y SU COMPARACIÓN CON LA REFERENCIA DE LOS CENTROS PARA EL CONTROL Y PREVENCIÓN DE ENFERMEDADES (CDC)

Resumen

Introducción: **la evaluacion del grosor de los pliegues subcutáneos es una medida objetiva de la adiposidad. Es por tanto una herramienta útil para el diagnóstico nutricional y la prevención del riesgo metabólico asociado al exceso de grasa en la infancia y adolescencia.**

Objetivo: **proporcionar valores percentilares de los pliegues adiposos subcutáneos subescapular y tricipital para escolares hispanoamericanos y compararlos con los valores publicados por los Centros para el Control y Prevención de Enfermedades (CDC) de los Estados Unidos, que comunmente se emplean como referencia en estos países.**

Métodos: **se midió el pliegue subescapular y tricipital en 9.973 escolares entre 4 y 19 años procedentes de España, Argentina, Cuba, Venezuela y México con un calibre Holtain de 0,2 mm de precisión. Los percentiles fueron calculados mediante el método estadístico LMS y presentados en tablas divididas en intervalos de seis meses y en gráficos de curvas. La diferencia entre los valores medios hispanoamericanos y los valores del CDC se muestran para el P3, P50 y P97 en mm, y también gráficamente.**

Resultados: **las medidas de los pliegues subcutáneos se incrementan obviamente con la edad pero, en niños, este incremento es mucho más marcado en los percentiles superiores entre los 8 y 13 años; este máximo es alcanzado antes que en la referencia del CDC. En ambos sexos, todos los percentiles analizados fueron superiores en los escolares hispanoamericanos, exceptuando el P97 por**

analized in Hispanic American schoolchildren were higher than the CDC reference except P97 up to 10 or 13 years that was notably smaller.

Conclusions: **the skinfolds percentiles of Hispanic American children and adolescents differ from CDC that are usually used as reference. The values of subscapular and triceps skinfolds provided in this study, could be applied to populations of a similar ethnic background, especially in comparative studies of body composition.**

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Key words: *Adiposity. Anthropometry. Spain. Latin-america. Childhood. Adolescence.*

encima de los 10 o 13 años, donde resultó notablemente inferior.

Conclusiones: **los percentiles de pliegues adiposos de los niños y adolescentes hispanoamericanos difieren de la referencia del CDC. Los valores del pliegie subescapular y tricipital proporcionados en este estudio podrían ser aplicados en poblaciones de similar origen étnico, especialmente en estudios comparativos de la composición corporal.**

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Palabras clave: *Adiposidad. Antropometría. España. Latinoamérica. Infancia. Adolescencia.*

Abbreviations

CDC: Centers for Disease Control and Prevention.
BMI: Body Mass Index.
IOTF: International Obesity Task Force.
NHANES: National Health and Nutrition Examination Survey.
WHO: World Health Organization.

Introduction

The prevalence of obesity shows a positive secular trend in all age groups in developed or industrialized and developing countries in all continents[1,2]. Based on the trend of obesity observed in America between 1985 and 2005, a prevalence of 15% obesity and 40% of overweight[2] was estimated for 2010 on this continent. In developing countries, as is the case in many Latin American countries, obesity –in addition– coexists with poverty, malnutrition with overweight or double burden of malnutrition, setting a new nutritional paradigm[3].

However, significant interpopulation differences in the prevalence of obesity[4], the distribution of adiposity by sex before and after puberty[5] and density of fat-free mass were detected which have been interpreted as conditioned by ethnicity[6]. Interethnic differences have also been observed between diverse assessment methods in human body composition, such as bioelectrical impedance analysis and dual-energy X-ray absorptiometry[7]and in the distribution of the visceral and subcutaneous fatty compartments of the body, variations that may be attenuated or masked by obesity[8]. It is therefore important to define the extent of adiposity in children from different ethnic groups.

The validity of the Body Mass Index (BMI) as an indicator of body fat and cardiometabolic risk in young population has also been questioned because it has limitations in distinguishing fat from lean mass[9]. Due to its low cost and non-invasive procedure, evaluation of skinfolds is one of the most objective anthropometric measurements to assess adiposity for its high compatibility with other methods of direct measurement of body fat mass[10]. Excess adiposity assessed by skinfolds successfully associates in adolescents with increased blood lipids (triglycerides and cholesterol) and insulin resistance, markers for increased risk of metabolic syndrome[11].

Between 2005 and 2008 a multicenter collaborative project was conducted to collect anthropometric data in children and adolescents from different localities of Spain, Venezuela, Argentina, Cuba and Mexico. Based on these data, skinfold centiles of biceps, triceps, subscapular and suprailiac folds were calculated using the LMS method.

Objective

In order to assess the extent of interethnic differences in adiposity in large-scale studies, the aim of the present study was to provide percentiles of subscapular and triceps skinfolds for Hispanic American young people and compare them with the values obtained from the Centers for Disease Control and Prevention (CDC)[12] elaborated for United States children and adolescentes that commonly have been used as a reference in most of these Hispanic American countries.

Methods

Origin and composition of the sample

The sample consisted of 9973 healthy students (4964 boys, 5009 girls) between 4 and 19 years old, without obvious pathologies at the time of measurement, attending public schools of middle and low socioeconomic level at different locations in Argentina (Catamarca and Jujuy), Cuba (Havana), Spain (Madrid), Mexico (Hermosillo), and Venezuela (Caracas and Merida).

The participants' date of birth was obtained from their national identity document or the School Registry and the decimal age was calculated[13]. Data were grouped by gender and in 31 age groups with an interval of half a year.

Measurements

After obtaining informed consent from parents or guardians and abiding by the rules of Helsinki[14], anthropometric measurements were performed between 2005-2008 by trained personnel, with approved instruments and in accordance with techniques recommended by the International Biological Programme[15].

Body weight (kg) was measured with a lever balance (100 g precision) in light clothing, and height (cm) with a vertical anthropometer (1 mm accuracy). Based on these measurements, BMI was calculated and using the criteria of the International Obesity Task Force (IOTF) developed by Cole *et al*.[16,17]. The prevalence of thinness, overweight and obesity were determined by sex in the following age groups: 4-8 years, 9-12 years and >12 years.

Skinfolds were measured with a Holtain constant pressure adipometer and 2 tenths of millimeter accuracy. Instruments were calibrated at the beginning of each anthropometric session. With the subject's arm extended and relaxed, the skinfold was taken at the mesobraquial region in the acromial-radial midline with the thumb of our left hand a pinch of skin and adipose tissue over the triceps not including muscle tissue. The subscapular skinfold was taken by holding the adipose tissue at the inferior angle of the scapula at its vertebral border, obliquely downward and outward at an angle of 45º with the horizontal line passing through the inferior border of the scapula[18].

Statistical Analysis

The dispersion of raw data was analyzed and outliers were deleted using as cutoff ±4 SD; this criterion eliminated 84 cases. The LMS method was applied to calculate percentiles, as it summarizes the changing distribution of the anthropometric measurements according to age using the L, M and S curves representing the skewness (lambda), median (mu) and coefficient of variation (sigma), respectively. The LMS method uses the Box-Cox transformation to adjust the distribution of anthropometric data to a normal distribution, essentially minimizing the effects of asymmetry[19]. The L, M and S parameters were calculated according to the method of penalized maximum likelihood[19]. The values of L, M and S centiles were used to calculate according to the following formula[20,21]:

$$C = M * 1 * LSZ * 1/L$$

where L, M and S were the values calculated for each age and Z was the corresponding percentile needed (3, 5, 10, 25, 50, 75, 90, 95 and 97). The data processing was performed using the LMS ChartMaker Pro (The Institute of Child Health, London) software[22]. Q tests for fit were used to assess the global goodness of fit of models.

The 3, 50 and 97 percentiles of triceps and subscapular skinfold thickness were graphically compared with the respective values of the CDC reference[12] also calculated using the same LMS method.

To examine the discrepancy in the calculated percentiles by age and sex, with respect to the CDC reference[12], differences in millimeters and percentage were calculated using the following formula[21]:

100log (centile of the reference / calculated centile)

Results

Table I shows the nutritional status of the Hispanic American sample according to the classification criteria of the IOTF. As can be seen, while the proportion of normally nourished schoolchildren remained constant along the ontogenetic period analyzed, thinness decreased as increased the percentage of students who were included in the categories of overweight or obese.

Figures 1 (a,b) and 2 (a,b) represent the percentiles of subscapular and triceps folds for girls and boys. The

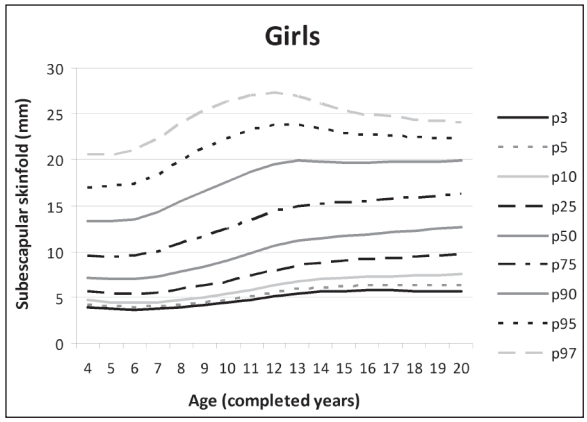

Fig. 1.a.—Subescapular skinfold thickness percentiles representation for Hispanic American girls from 4 to 19 years.

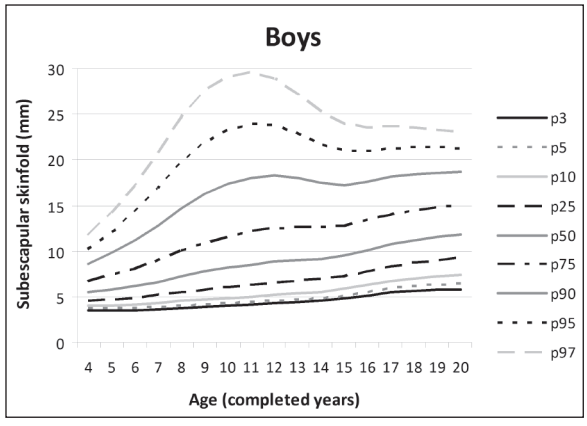

Fig. 1.b.—Subescapular skinfold thickness percentiles representation for Hispanic American boys from 4 to 19 years.

Table I
Nutritional status distribution of the sample by age group

	Age (years)			
	4-8	*9-12*	*>12*	*Total*
Thinness (%)	8.3	6.7	6.8	7.1
Normal weight (%)	71.7	69.2	69.9	70.0
Overweight (%)	14.5	18.5	19.1	17.9
Obesity (%)	5.5	5.6	4.2	4.9

numeral values of these measurements and LMS parameters are shown in tables II to V for both sexes and for age groups ranges of 6 months from 4 to 19 years old. Subscapular skinfolds measurements increased with age in both sexes but, in boys, this increase is much more marked between 8 and 13 years in top percentiles (90, 95 and 97).

Compared to the CDC reference this increase is reached earlier and then it experiences a decline as from 13 years in both sexes (Figs. 3a, 3b). A similar trend is observed in triceps skinfold in which the extreme

Table II
Subscapular skinfold percentiles and L, M and S values of hispanic american girls

Age (years)	*P3*	*P5*	*P10*	*P25*	*P50*	*P75*	*P90*	*P95*	*P97*	*L*	*M*	*S*
4	3.96	4.21	4.65	5.60	7.12	9.54	13.30	17.01	20.52	-0.74	7.12	0.39
4.5	3.86	4.11	4.55	5.50	7.04	9.48	13.27	17.02	20.55	-0.71	7.04	0.40
5	3.77	4.02	4.47	5.42	6.97	9.44	13.28	17.05	20.61	-0.69	6.97	0.41
5.5	3.71	3.96	4.40	5.37	6.94	9.44	13.34	17.16	20.75	-0.67	6.94	0.41
6	3.66	3.92	4.38	5.36	6.96	9.52	13.49	17.39	21.02	-0.64	6.96	0.42
6.5	3.66	3.92	4.39	5.40	7.05	9.69	13.78	17.77	21.48	-0.62	7.05	0.43
7	3.71	3.98	4.46	5.51	7.23	9.98	14.23	18.35	22.16	-0.59	7.23	0.44
7.5	3.80	4.09	4.59	5.70	7.50	10.40	14.85	19.14	23.07	-0.57	7.50	0.44
8	3.91	4.21	4.74	5.91	7.81	10.85	15.51	19.96	24.00	-0.54	7.81	0.45
8.5	4.01	4.32	4.88	6.10	8.09	11.27	16.09	20.64	24.75	-0.52	8.09	0.45
9	4.11	4.44	5.02	6.30	8.37	11.67	16.61	21.23	25.34	-0.49	8.37	0.45
9.5	4.23	4.57	5.19	6.52	8.68	12.09	17.14	21.79	25.87	-0.47	8.68	0.45
10	4.37	4.73	5.38	6.77	9.03	12.54	17.68	22.32	26.33	-0.44	9.03	0.45
10.5	4.54	4.92	5.59	7.05	9.40	13.02	18.21	22.81	26.72	-0.41	9.40	0.45
11	4.72	5.12	5.83	7.36	9.79	13.50	18.71	23.24	27.02	-0.38	9.79	0.45
11.5	4.91	5.33	6.07	7.67	10.19	13.96	19.16	23.58	27.21	-0.35	10.19	0.44
12	5.10	5.54	6.32	7.98	10.56	14.37	19.52	23.80	27.26	-0.32	10.56	0.44
12.5	5.27	5.73	6.54	8.25	10.89	14.71	19.76	23.88	27.15	-0.28	10.89	0.43
13	5.42	5.89	6.73	8.48	11.15	14.96	19.88	23.81	26.89	-0.25	11.15	0.42
13.5	5.53	6.02	6.87	8.65	11.34	15.12	19.89	23.63	26.53	-0.21	11.34	0.41
14	5.60	6.10	6.97	8.78	11.48	15.20	19.83	23.39	26.11	-0.18	11.48	0.41
14.5	5.65	6.16	7.04	8.88	11.58	15.25	19.74	23.13	25.69	-0.14	11.58	0.40
15	5.68	6.20	7.10	8.96	11.67	15.30	19.66	22.92	25.35	-0.10	11.67	0.40
15.5	5.71	6.24	7.16	9.05	11.77	15.38	19.65	22.78	25.10	-0.06	11.77	0.39
16	5.73	6.28	7.22	9.14	11.89	15.49	19.67	22.71	24.94	-0.02	11.89	0.39
16.5	5.75	6.31	7.28	9.23	12.01	15.60	19.72	22.68	24.82	0.02	12.01	0.39
17	5.75	6.32	7.32	9.31	12.12	15.70	19.75	22.63	24.70	0.06	12.12	0.39
17.5	5.73	6.32	7.34	9.37	12.20	15.77	19.75	22.55	24.54	0.11	12.20	0.39
18	5.71	6.32	7.36	9.43	12.28	15.83	19.74	22.45	24.38	0.15	12.28	0.38
18.5	5.70	6.32	7.39	9.49	12.37	15.91	19.75	22.39	24.25	0.19	12.37	0.38
19	5.69	6.33	7.43	9.57	12.47	16.00	19.78	22.35	24.15	0.24	12.47	0.38

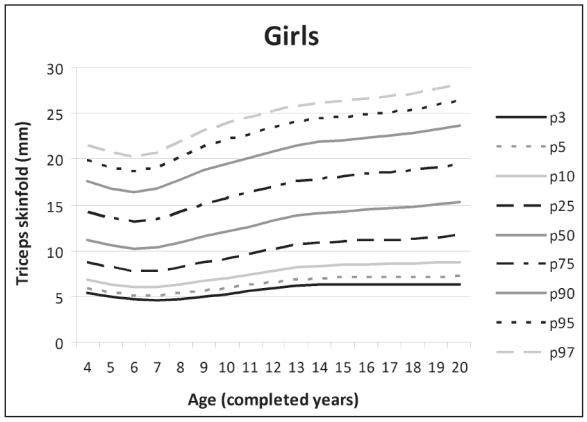

Fig. 2.a.—Triceps skinfold thickness percentiles representation for Hispanic American girls from 4 to 19 years.

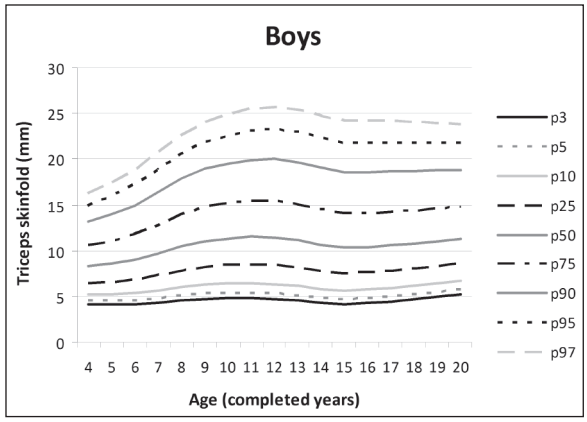

Fig. 2.b.—Triceps skinfold thickness percentiles representation for Hispanic American girls from 4 to 19 years.

Table III
Subscapular skinfold percentiles and L, M and S values of hispanic american boys

Age (years)	*P3*	*P5*	*P10*	*P25*	*P50*	*P75*	*P90*	*P95*	*P97*	*L*	*M*	*S*
4	3.55	3.72	4.01	4.60	5.49	6.79	8.62	10.25	11.67	-0.95	5.49	0.29
4.5	3.55	3.72	4.03	4.66	5.63	7.09	9.18	11.10	12.83	-0.92	5.63	0.31
5	3.54	3.73	4.05	4.73	5.79	7.40	9.78	12.04	14.11	-0.89	5.79	0.33
5.5	3.54	3.74	4.08	4.81	5.95	7.73	10.44	13.07	15.54	-0.86	5.95	0.35
6	3.56	3.77	4.13	4.91	6.15	8.11	11.16	14.20	17.13	-0.83	6.15	0.37
6.5	3.60	3.81	4.20	5.03	6.38	8.54	11.96	15.46	18.88	-0.80	6.38	0.39
7	3.65	3.88	4.29	5.18	6.64	9.01	12.84	16.81	20.76	-0.77	6.64	0.40
7.5	3.71	3.96	4.40	5.35	6.92	9.52	13.77	18.23	22.70	-0.74	6.92	0.42
8	3.78	4.04	4.51	5.53	7.22	10.04	14.69	19.62	24.59	-0.71	7.22	0.44
8.5	3.85	4.12	4.62	5.70	7.50	10.53	15.55	20.88	26.24	-0.68	7.50	0.45
9	3.90	4.19	4.71	5.84	7.75	10.96	16.28	21.92	27.56	-0.65	7.75	0.46
9.5	3.95	4.25	4.78	5.97	7.96	11.32	16.87	22.70	28.50	-0.62	7.96	0.47
10	3.99	4.30	4.86	6.09	8.16	11.63	17.34	23.28	29.11	-0.60	8.16	0.47
10.5	4.04	4.36	4.94	6.21	8.35	11.93	17.75	23.72	29.48	-0.57	8.35	0.48
11	4.10	4.43	5.03	6.34	8.54	12.19	18.06	23.98	29.60	-0.55	8.54	0.48
11.5	4.17	4.51	5.12	6.47	8.72	12.41	18.25	24.02	29.41	-0.53	8.72	0.48
12	4.24	4.59	5.22	6.59	8.86	12.55	18.29	23.84	28.92	-0.50	8.86	0.47
12.5	4.31	4.66	5.30	6.69	8.97	12.62	18.18	23.44	28.16	-0.48	8.97	0.47
13	4.37	4.73	5.38	6.77	9.05	12.63	17.97	22.89	27.22	-0.46	9.05	0.46
13.5	4.45	4.81	5.46	6.86	9.12	12.62	17.71	22.29	26.23	-0.44	9.12	0.45
14	4.53	4.90	5.56	6.97	9.21	12.63	17.47	21.71	25.29	-0.42	9.21	0.44
14.5	4.65	5.02	5.69	7.11	9.34	12.69	17.30	21.25	24.51	-0.39	9.34	0.43
15	4.79	5.17	5.86	7.30	9.54	12.83	17.26	20.96	23.96	-0.36	9.54	0.42
15.5	4.96	5.36	6.06	7.54	9.81	13.08	17.38	20.89	23.69	-0.33	9.81	0.41
16	5.14	5.56	6.29	7.82	10.12	13.39	17.60	20.97	23.61	-0.29	10.12	0.40
16.5	5.32	5.76	6.52	8.09	10.44	13.73	17.86	21.10	23.60	-0.26	10.44	0.39
17	5.48	5.93	6.72	8.34	10.74	14.04	18.11	21.23	23.61	-0.21	10.74	0.39
17.5	5.59	6.06	6.88	8.55	11.00	14.30	18.30	21.31	23.58	-0.17	11.00	0.38
18	5.68	6.17	7.01	8.73	11.21	14.51	18.43	21.35	23.51	-0.12	11.21	0.38
18.5	5.74	6.24	7.11	8.87	11.39	14.68	18.53	21.34	23.41	-0.07	11.39	0.37
19	5.78	6.30	7.20	9.00	11.54	14.83	18.61	21.32	23.30	-0.02	11.54	0.37

Table IV
Triceps skinfold percentiles and L, M and S values of hispanic american girls

Age (years)	*P3*	*P5*	*P10*	*P25*	*P50*	*P75*	*P90*	*P95*	*P97*	*L*	*M*	*S*
4	5.40	5.94	6.87	8.69	11.17	14.23	17.57	19.87	21.50	0.23	11.17	0.37
4.5	5.17	5.71	6.62	8.41	10.87	13.90	17.20	19.48	21.09	0.23	10.87	0.37
5	4.96	5.49	6.39	8.16	10.59	13.59	16.87	19.12	20.72	0.23	10.59	0.38
5.5	4.78	5.30	6.19	7.95	10.37	13.35	16.61	18.85	20.43	0.23	10.37	0.38
6	4.65	5.17	6.06	7.82	10.23	13.22	16.48	18.72	20.30	0.24	10.23	0.39
6.5	4.58	5.10	5.99	7.77	10.21	13.22	16.51	18.78	20.37	0.24	10.21	0.39
7	4.58	5.11	6.02	7.83	10.32	13.40	16.76	19.07	20.70	0.24	10.32	0.40
7.5	4.66	5.20	6.15	8.01	10.59	13.76	17.23	19.60	21.28	0.24	10.59	0.40
8	4.78	5.34	6.32	8.26	10.92	14.21	17.78	20.24	21.97	0.24	10.92	0.40
8.5	4.90	5.49	6.50	8.51	11.25	14.64	18.31	20.82	22.59	0.24	11.25	0.40
9	5.03	5.64	6.68	8.74	11.56	15.03	18.77	21.33	23.13	0.24	11.56	0.40
9.5	5.16	5.79	6.86	8.98	11.86	15.39	19.18	21.77	23.58	0.25	11.86	0.40
10	5.30	5.94	7.04	9.21	12.14	15.72	19.55	22.15	23.96	0.26	12.14	0.40
10.5	5.44	6.10	7.23	9.44	12.42	16.03	19.88	22.48	24.29	0.27	12.42	0.39
11	5.59	6.27	7.42	9.68	12.71	16.35	20.21	22.80	24.61	0.29	12.71	0.39
11.5	5.74	6.44	7.63	9.93	13.00	16.68	20.55	23.14	24.94	0.30	13.00	0.38
12	5.90	6.61	7.82	10.17	13.29	17.00	20.89	23.49	25.28	0.32	13.29	0.38
12.5	6.03	6.77	8.01	10.40	13.57	17.31	21.22	23.81	25.61	0.33	13.57	0.38
13	6.14	6.89	8.16	10.60	13.81	17.58	21.50	24.10	25.89	0.34	13.81	0.37
13.5	6.22	6.98	8.28	10.75	13.99	17.80	21.73	24.32	26.10	0.36	13.99	0.37
14	6.26	7.04	8.35	10.86	14.13	17.95	21.88	24.47	26.24	0.38	14.13	0.37
14.5	6.28	7.07	8.39	10.93	14.22	18.05	21.98	24.56	26.32	0.39	14.22	0.37
15	6.28	7.08	8.43	10.99	14.30	18.15	22.07	24.64	26.40	0.41	14.30	0.37
15.5	6.29	7.11	8.47	11.06	14.40	18.27	22.20	24.76	26.52	0.42	14.40	0.37
16	6.30	7.13	8.51	11.13	14.50	18.39	22.33	24.90	26.65	0.43	14.50	0.37
16.5	6.30	7.13	8.53	11.18	14.58	18.49	22.45	25.02	26.77	0.44	14.58	0.37
17	6.29	7.13	8.55	11.22	14.65	18.58	22.55	25.13	26.88	0.45	14.65	0.37
17.5	6.28	7.13	8.56	11.26	14.72	18.68	22.67	25.26	27.02	0.46	14.72	0.37
18	6.27	7.14	8.59	11.32	14.82	18.81	22.83	25.43	27.20	0.47	14.82	0.37
18.5	6.28	7.16	8.63	11.40	14.94	18.98	23.03	25.65	27.43	0.47	14.94	0.38
19	6.29	7.19	8.68	11.49	15.08	19.16	23.26	25.90	27.69	0.47	15.08	0.38

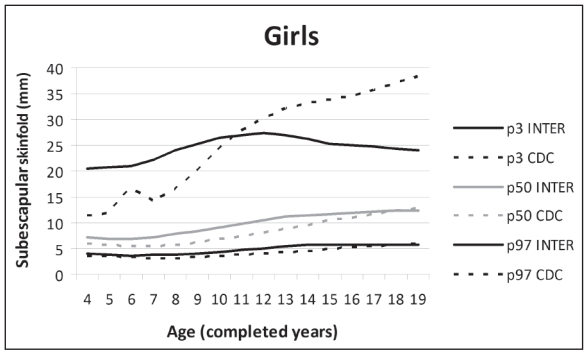

Fig. 3.a.—Graphical comparison of percentiles 3, 50 and 97 values of subscapular skinfold thickness between Hispanic American girls (INTER) and the reference of Centers for Disease Control and Prevention (CDC).

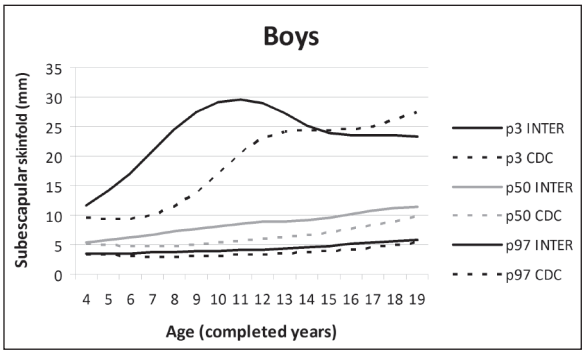

Fig. 3.b.—Graphical comparison of percentiles 3, 50 and 97 values of subscapular skinfold thickness between Hispanic American boys (INTER) and the reference of Centers for Disease Control and Prevention (CDC).

Table V
Triceps skinfold percentiles and L, M and S values of hispanic american boys

Age (years)	*P3*	*P5*	*P10*	*P25*	*P50*	*P75*	*P90*	*P95*	*P97*	*L*	*M*	*S*
4	4.21	4.59	5.23	6.51	8.30	10.58	13.16	15.00	16.32	0.05	8.30	0.36
4.5	4.19	4.58	5.24	6.57	8.44	10.82	13.53	15.46	16.86	0.04	8.44	0.37
5	4.18	4.57	5.26	6.64	8.59	11.09	13.93	15.96	17.43	0.05	8.59	0.38
5.5	4.18	4.59	5.31	6.75	8.78	11.41	14.39	16.53	18.07	0.05	8.78	0.39
6	4.21	4.64	5.39	6.90	9.04	11.80	14.95	17.20	18.83	0.05	9.04	0.40
6.5	4.28	4.73	5.51	7.10	9.36	12.28	15.62	18.01	19.73	0.06	9.36	0.41
7	4.37	4.85	5.67	7.35	9.74	12.83	16.37	18.89	20.72	0.07	9.74	0.41
7.5	4.48	4.98	5.85	7.61	10.13	13.40	17.13	19.79	21.71	0.08	10.13	0.42
8	4.58	5.11	6.02	7.87	10.51	13.94	17.84	20.63	22.65	0.09	10.51	0.42
8.5	4.68	5.23	6.17	8.09	10.84	14.40	18.46	21.36	23.45	0.10	10.84	0.43
9	4.76	5.32	6.29	8.26	11.09	14.76	18.94	21.92	24.07	0.10	11.09	0.43
9.5	4.80	5.37	6.35	8.37	11.25	14.99	19.26	22.30	24.50	0.10	11.25	0.43
10	4.82	5.40	6.40	8.44	11.37	15.17	19.51	22.61	24.84	0.10	11.37	0.43
10.5	4.84	5.42	6.43	8.50	11.47	15.34	19.76	22.92	25.21	0.10	11.47	0.44
11	4.85	5.43	6.45	8.53	11.54	15.46	19.97	23.19	25.53	0.09	11.54	0.44
11.5	4.82	5.40	6.42	8.51	11.53	15.49	20.05	23.33	25.70	0.09	11.53	0.44
12	4.76	5.34	6.35	8.43	11.45	15.42	20.02	23.33	25.74	0.08	11.45	0.45
12.5	4.68	5.25	6.25	8.31	11.32	15.29	19.90	23.24	25.67	0.07	11.32	0.45
13	4.58	5.14	6.12	8.16	11.13	15.08	19.69	23.03	25.48	0.07	11.13	0.46
13.5	4.47	5.02	5.98	7.98	10.91	14.82	19.40	22.74	25.18	0.06	10.91	0.46
14	4.37	4.90	5.84	7.80	10.68	14.53	19.07	22.38	24.82	0.05	10.68	0.46
14.5	4.28	4.80	5.73	7.64	10.48	14.27	18.76	22.04	24.46	0.05	10.48	0.46
15	4.24	4.75	5.66	7.55	10.35	14.11	18.55	21.81	24.21	0.04	10.35	0.46
15.5	4.25	4.76	5.66	7.55	10.33	14.07	18.50	21.75	24.14	0.04	10.33	0.46
16	4.30	4.81	5.72	7.61	10.39	14.12	18.55	21.79	24.18	0.04	10.39	0.46
16.5	4.38	4.89	5.80	7.69	10.48	14.20	18.61	21.83	24.21	0.04	10.48	0.45
17	4.47	4.99	5.91	7.80	10.58	14.29	18.66	21.86	24.21	0.04	10.58	0.45
17.5	4.59	5.11	6.02	7.92	10.69	14.37	18.69	21.85	24.17	0.04	10.69	0.44
18	4.71	5.23	6.15	8.04	10.80	14.45	18.72	21.83	24.11	0.04	10.80	0.43
18.5	4.84	5.36	6.29	8.18	10.92	14.53	18.74	21.80	24.03	0.04	10.92	0.43
19	4.98	5.51	6.43	8.32	11.05	14.62	18.77	21.77	23.97	0.04	11.05	0.42

increase is also in top percentiles and being much more pronounced in boys (Figs. 4a, 4b). In general, in the female serie, the values of this study are below those corresponding to the CDC reference for all percentiles whilst in male serie, this values are lower only for 97th percentil.

Table VI represent the difference in mm between percentiles 3, 50 and 97 of the subscapular and triceps skinfolds with respect to the CDC reference. The difference were positive when the CDC reference value was greater than the value of Hispanic American sample and they were negative when the opposite occurred. In general, the discrepancy between values of both skinfolds in Hispanic American and CDC reference is practically null in P3 values being around cero. For P50 the discrepancy are higher with values around 2 points and for the P97 there is the highest differences with values that ranged from cero in central ages until 9 or 14 in the extreme ages.

In relation to subscapular skinfold, there are generally negative values of the differences what it means that Hispanic American children and adolescent have

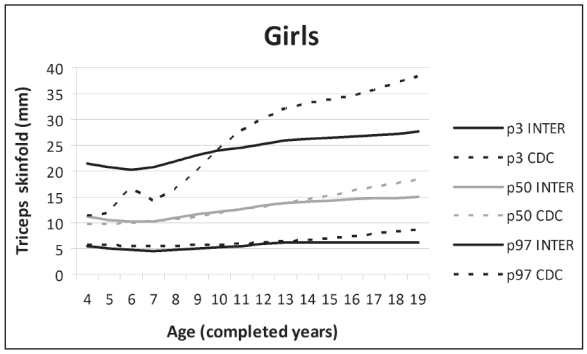

Fig. 4.a.—Graphical comparison of percentiles 3, 50 and 97 values of triceps skinfold thickness between Hispanic American girls (INTER) and the reference of Centers for Disease Control and Prevention (CDC).

Fig. 4.b.—Graphical comparison of percentiles 3, 50 and 97 values of triceps skinfold thickness between Hispanic American boys (INTER) and the reference of Centers for Disease Control and Prevention (CDC).

Table VI
Differences in mm between Hispanic American mean values and CDC reference values of skinfolds percentiles 3, 50 and 97 in both sexes

Age (years)	Subscapular skinfold						Triceps skinfold					
	Boys			Girls			Boys			Girls		
	3	50	97	3	50	97	3	50	97	3	50	97
4	-0.13	-0.23	-2.18	-0.30	-1.01	-6.27	1.24	0.69	-0.78	0.54	-0.76	-2.47
4.5	-0.21	-0.49	-3.46	-0.29	-1.07	-6.59	1.09	0.38	-1.30	0.62	-0.63	-2.22
5	-0.26	-0.77	-4.81	-0.29	-1.14	-6.87	0.91	0.04	-1.83	0.69	-0.51	-1.97
5.5	-0.35	-1.05	-6.27	-0.31	-1.23	-7.12	0.73	-0.32	-2.40	0.75	-0.40	-1.71
6	-0.45	-1.36	-7.81	-0.37	-1.37	-3.36	0.52	-0.74	-3.01	0.79	-0.32	-1.44
6.5	-0.56	-1.67	-9.36	-0.44	-1.54	-7.55	0.31	-1.16	-3.62	0.80	-0.26	-1.18
7	-0.64	-1.94	-10.8	-0.49	-1.71	-7.68	0.12	-1.57	-4.13	0.80	-0.25	-0.95
7.5	-0.71	-2.18	-12.1	-0.54	-1.91	-7.69	-0.04	-1.89	-4.42	0.75	-0.29	-0.78
8	-0.77	-2.40	-13.1	-0.60	-2.06	-7.36	-0.15	-2.12	-4.45	0.69	-0.33	-0.56
8.5	-0.81	-2.57	-13.7	-0.63	-2.13	-6.52	-0.23	-2.25	-4.15	0.64	-0.32	-0.15
9	-0.81	-2.68	-13.7	-0.64	-2.14	-5.26	-0.27	-2.25	-3.53	0.60	-0.28	0.39
9.5	-0.81	-2.72	-13.1	-0.76	-2.15	-3.78	-0.25	-2.15	-2.63	0.57	-0.23	1.00
10	-0.79	-2.74	-12.0	-0.80	-2.19	-2.24	-0.22	-2.02	-1.63	0.52	-0.18	1.62
10.5	-0.79	-2.77	-10.6	-0.86	-2.24	-0.74	-0.21	-1.92	-0.75	0.44	-0.15	2.23
11	-0.80	-2.82	-9.09	-0.93	-2.30	0.64	-0.22	-1.86	0.01	0.36	-0.14	2.78
11.5	-0.82	-2.87	-7.45	-1.01	-2.37	1.89	-0.22	-1.80	0.68	0.27	-0.14	3.25
12	-0.85	-2.89	-5.85	-1.07	-2.39	3.03	-0.23	-1.75	1.19	0.20	-0.15	3.67
12.5	-0.87	-2.87	-4.35	-1.11	-2.36	4.11	-0.24	-1.74	1.52	0.16	-0.11	4.09
13	-0.86	-2.82	-3.01	-1.11	-2.26	5.14	-0.25	-1.74	1.70	0.17	-0.02	4.55
13.5	-0.86	-2.72	-1.85	-1.06	-2.08	6.11	-0.27	-1.75	1.78	0.23	0.15	5.06
14	-0.83	-2.62	-0.87	-0.96	-1.84	6.97	-0.31	-1.77	1.78	0.35	0.39	5.62
14.5	-0.82	-2.52	-0.11	-0.83	-1.57	5.91	-0.34	-1.81	1.73	0.51	0.69	6.20
15	-0.82	-2.47	0.42	-0.68	-1.29	10.3	-0.40	-1.89	1.59	0.69	1.01	6.75
15.5	-0.84	-2.47	0.70	-0.54	-1.04	8.98	-0.50	-2.03	1.34	0.89	1.32	7.21
16	-0.87	-2.49	0.90	-0.41	-0.82	9.63	-0.60	-2.21	-1.41	1.09	1.62	7.63
16.5	-0.88	-2.50	1.14	-0.30	-0.61	10.3	-0.72	-2.35	0.99	1.30	1.94	8.03
17	-0.87	-2.46	1.47	-0.20	-0.41	11.1	-0.82	-2.46	1.06	1.53	2.26	8.37
17.5	-0.80	-2.35	1.96	-0.09	-0.19	11.9	-0.92	-2.50	1.35	1.75	2.56	8.67
18	-0.70	-2.15	2.64	0.01	0.01	12.7	-0.99	-2.48	1.85	1.97	2.83	8.89
18.5	-0.56	-1.90	3.44	0.09	0.20	13.4	-1.04	-2.42	2.53	2.16	3.07	9.05
19	-0.41	-1.60	4.28	0.16	0.37	14.1	-1.10	-2.34	3.26	2.34	3.29	9.17
Mean	-0.70	-2.20	-4.81	-0.56	-1.45	1.85	-0.18	-1.68	-2.20	0.81	0.50	3.25

higher subscapular adiposity. However, p97 of girls up to 11 years are lower than those in CDC and this discrepancy clearly increase with age rising 14 positive points.

The difference for triceps skinfold between Hispanic American children and adolescent and the CDC reference are less evident that for subscapular skinfold rising smallest values especially in boys for the three percentiles. The greatest difference for triceps skinfold is observed for the P97 in girls up to 11 years.

Discussion

This study was the first to consider a child and adolescent group of Hispanic American origin to establish skinfold percentiles. The relevance of this analysis was based on the finding of an increase in skinfolds at a rate of 0.4 to 0.5 mm per decade over the 1951-2003 period analyzed by Olds[23] using information provided by 154 studies on more than 458,547 children and adolescents in 30 developed countries. This increase in skinfold thickness was consistent with increased BMI in the world and the obesity epidemic[2,24,25]. However, the prevalence of excess weight (overweight and obesity) observed in the sample of this study was lower than the reported values for the different countries also participating in the Olds[23] study: Argentina[26], Cuba[27], Mexico[28] and Spain[29].

The differences found in skinfold percentiles over the years in the Olds study[23] might primarily arise in terms of the methodology used to calculate them. Currently there are a number of statistical methods based on the adjustment of mathematical models controlling kurtosis and/or asymmetry of raw anthropometric data and adequately represent their changes and trends in terms of age. One such tool is the LMS method, which also describes the temporal changes of anthropometric measurements, and provides a set of statistical parameters that enable further biological interpretation of growth and interpopulation comparison[19,30,31]. The results obtained in the present research are comparable with those of the CDC reference because they were obtained using the same LMS method but there is a methodological difference between both studies that is related to the adipometer used to measure the skinfolds. In all national health surveys conducted in the United States, skinfolds were measured to the nearest 0.5 mm by using Lange calipers, except for the III National Health and Nutrition Examination Survey (NHANES) in which Holtain calipers were used with a sensitivity of 0.2 mm[12]. In the present work, however, all the children were measured with a Holtain caliper by highly qualified staff.

The gratest difference between this study and the CDC reference relate to the ethnicity of the populations analyzed but also the age and characteristics of the sample. The ethnic composition of Latin American populations is the convergence in varying degrees, according to their geographical position in the vast territory of the Americas, of three parental populations: Amerindian, European and African. The percentage of genetic mixing of these populations, estimated with different molecular markers, varies depending on this geographical distribution and differential parental contribution and is a valuable indicator of population and migration dynamics[32]. In the CDC reference children were identified from the ethnical-racial point of view as black or white, but the values of percentiles in tables were presented together, as opposed to graphical displays where black boys and girls showed P50 values of triceps skinfold lower than those of white children[12]. In the subscapular skinfold these differences were less evident in the graphical display of the publication[12]. As for the age of the samples, anthropometric data used in the present study were collected in 2005-2008 whilst the CDC reference mix data from the National Health Examination Survey II and III conducted between 1963 and 1970 and with the NHANES I, II and III which took place between 1971 and 1994. In addition, the children and adolescents included in the present study were schoolchildren without pathologies, attending public schools and of middle socioeconomic conditions. whilst the CDC reference data corresponded to non-prescriptively selected children and adolescents representing the entire civilian, noninstitutionalized population of the United States.

Studies on body composition and particularly skinfold measurement are very scarce in Hispanic American populations and most of the existing ones have been performed in resident or migrant children in the United States. Comparisons between the Hispanic American sample and the CDC reference conducted in this study were consistent with the differences in the thickness of the subscapular, triceps, suprailiac and medial calf skinfolds found between white American children and American children of Mexican origin included in NHANES (1982-1984) who tend to have thicker skinfolds[33]; however the measurements were not comparable because of the different calipers used, the age groups made using different criteria and because were not calculated using the LMS method.

The comparison between the hispanic american skinfolds of this study with respect to the CDC reference also indicated that there were differences in the distribution of adipose tissue. Interpopulational differences were observed in the fat distribution in terms of the trunk (main) and extremities (peripheral) model[34] and that in adolescents, lower trunk extremity and upper trunk components accounted for 80% of the variance in fat distribution[35]. This was also evaluated in a oriental sample recruited using a non-random purposive sampling approach consisting of 578 children aged 8-10 years from China, Lebanon, Malaysia and Thailand, after controlling for height and weight there was a significant ethnic difference in biceps, triceps, subscapular, supraspinal, and medial calf skinfolds[36]. The Chinese and Thai children showed increased fatty

deposition in the trunk compared to the Malays, who in turn had higher values than the Lebanese. Specifically, the ratio of the subscapular to the triceps skinfolds (S/T ratio) in children of Asian Americans was higher with respect to the Mexican, European, and African ones[34] and white children from Arizona State, compared to Asian and American children of Hispanic American origin, presented a smaller android/gynoid fat ratio[35]. The results found in the present study partially confirmed these findings because the boys and girls evaluated showed greater central adiposity, based on the subscapular skinfold, than the children of the CDC reference, especially in 3 and 50 percentiles.

According to Freedman, at similar age stage and BMI-for-age, the body fatness of children and adolescents can differ by up to 5% across racial/ethnic groups[4]. In fact, the interpopulation differences in the content and distribution of body fat, can be shown even within this Hispanic American sample that have a closer ehtnic origin compared with the United States sample. In a preliminary study based on 2436 infants and 6-9 year-old children from Spain, Mexico, Cuba, Venezuela and Argentina[37] it was revealed that: a) the higher total and relative adiposity corresponded to Mexican and Argentine series and the lower one to Venezuela, leaving Spain and Cuba in an intermediate position; b) with regard to the pattern of distribution of adiposity, the Spanish series featured a more peripheral trend, whereas the Argentine one showed a well pronounced backbone arrangement.

Given this background, Hispanic American children and adolescents evaluated in the present study showed a pattern of distribution of triceps and subscapular adiposity different from the CDC reference. While it has been proposed that theoretically human populations should follow a similar growth pattern in similar environmental conditions, it cannot be excluded that some of the interpopulation differences in this pattern may reflect not only the influence of the environment but also differences in the genetic potential[38]. The differences found in this research, in addition to ethnic and health characteristics of the samples, could be also attributed to the effect of secular changes in body composition because the most recent part of CDC sample is dated in 1994 whislt the measurements of this study were taken in 2005-2008.

Because BMI is of easy determination and because it has a high correlation with body fat, it is epidemiologically the most frequently used indicator to evaluate excess body fat in children and adolescents[25]. The most common criteria used to define overweight and obesity based on BMI among children are the proposed by three expert organizations: IOTF[16,17], CDC[39] and World Health Organization (WHO)[40]. The comparison of the prevalences of nutritional status obtained with these criteria in populations of different ethnic origin[41-44], including Latin American's[45-49], provide different results that can lead to erroneous conclusions. These studies also indicated the need to identify BMI cutoffs that are properly associated with an increased risk of health problems later in life[41]. The sensitivity and specificity of the criteria and cutoff points of BMI as predictors of body fat should be based on comparative analyses of body composition from subcutaneous skinfolds or other direct methods on estimating body fat, but such studies on school children have been scarce to date[44,49]. The percentiles of triceps and subscapular folds calculated in the present study can contribute to the purposes of such comparative studies.

Conclusions

The percentiles of triceps and subscapular skinfolds of contemporary and healthy Hispanic American children and adolescents from different localities in Spain, Argentina, Cuba, Mexico and Venezuela, differ substantially with respect to the american CDC reference that are commonly used for adiposity determination in these countries. Because adiposity depends on the reference used, the skinfold percentiles calculated in this study could be applied to people of a similar ethnicity, especially in comparative studies of body composition.

Acknowledgments

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Conflicts of interest

None.

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